Note 12

Speed Correlation Function (SCF)

In order to estimate the power of a 4-stroke piston engine before it is built, given Eqn. 3 of Note 10, it is necessary to predict the RPM at which Peak Power will be reached. This is the "Natural Peak Speed" (NP) as opposed to a "Rated Speed" which is limited mechanically or thermally so as to obtain a desired life under the constraints of the materials used.

In a study DST 6 February 2001 the author proposed a "Speed Correlation Function" (SCF) which could use geometry selected by the designer even at the pre-drawing stage to obtain an estimate of NP. The details of SCF are given on P.3.

Illustrations of SCF (PP.4 and 5)

Figs. 93/DST and 94/DST illustrate the quality of prediction of SCF, using regression analysis of data from CoY engines plus many others, divided into 2 basic groups:-

- Engines with "**Tortuous Inlets and Simple Exhausts**" (**T** group).
  In the CoY review these engines are in the 1st NA Era and the 1st PC Era.
  Fig. 93/DST shows that the average **T** group gradient is:-
  GS = NP/SCF = 38.6.
- Engines with **"Individual and Tuned Inlets and Exhausts**" (**I** group).
  These engines are in the 2nd NA and 3rd NA Eras.
  Fig. 94/DST shows that the average **I** group gradient is:-
  GS = NP/SCF = 47.4.

Thus the advantage of the improved "Breathability" of the **I** group is 23% higher NP over the **T** group.

The Figures show that the bulk of the 200-odd examples plotted is within Plus/Minus 10% of the averages but certain Exceptions(E) are noted on the charts:-

E1, E2 :	!926 – 1927 1.5 L Delages (Eg. 13) speeds as published; Note 5 explains the reasons why these numbers are believed to be exaggerated.
E3, E4 :	1954 – 1955 2.5 L Mercedes-Benz (Egs. 32, 33). The combination of Desmodromic valve-gear (see Note 15) and Direct Fuel Injection (see Note 34) enables these engines to escape some of the limitations of other units. Neither feature has been used in other CoY engines in this review.
E5 :	1965 1.5 L Coventry Climax 4 valves/cylinder (Eg. 44) A notoriously slow-burner, having no squish.
E6 :	1968 3 L Cosworth DFV (Eg. 47) Limited by cam-drive vibration, i.e. it was a "Rated" RPM.

Certain well-designed **T** group engines with 2 cylinders per carburetter choke actually fall into the **I** group performance area and these are shown as **X** on Fig. 94/DST. These engines are:-

1948 4.5 L Lago-Talbot T26C; 1948 1.4 L Gordini FB; 1948 1.7 L Lea-Francis Midget; 1951 1.7 L Offenhauser-Meyer-Drake Midget; 1998 5.7 L Chevrolet NASCAR.

Particular relation of SCF to CoY

Where the internal details required by SCF are available in CoY engines the values of GS and the relation to the **T** and **I** group averages (whichever is appropriate) are shown in Appendix 1 at Line 121. The mean deviation from the above quoted group values of GS, regardless of Plus/Minus sign, and excluding "repeats" for the same geometry, are:-

- For an 18 engine sample of the **T** group the mean deviation from **38.6** is **5.7**%*;
- For a 15 engine sample of the **I** group the mean deviation from **47.4** is **3.6**%**.

* Excluding the 1908 Mercedes (18.8%) because it had extremely unusual (unique) annular inlet valves. Also excluding E2.
** Excluding E3 to E6 and also excluding the 2000 Ferrari 049 (see below).

Deviation from SCF for 2000 Ferrari 049

The 2000 Ferrari 049 (Eg. 85) value for GS is 22% higher than the 47.4 average for the **I** group.

It is believed that this is associated with its high value of IVL/IVD at 0.384. It may be that some late 3rd NA Era engines are also faster than SCF suggests. The 1992 Honda RA122E/B (SO20, see Appendix 1) which had IVL/IVD = 0.315, was only 3.2% above 47.4 so a general change in IVL/IVD ratio may have occurred after that date.

[It may be remarked that a typical situation with all correlations based on an historical data series is that the last point does not fit! This is the reason why caution against expecting to find general relations is given in the section on Analysis 1906 - 2000 Part 2 starting on page 8.]

Possible SCF adjustment for high IVL/IVD

The deviation of the Ferrari 049 from GS = 47.4 *could* be adjusted if the IVL term within the Square Root bracket of SCF was altered from 1/3rd power to ½ power and perhaps this should be applied when IVL/IVD is higher than 1/3rd.

DST 27 January 2000
SCF.doc

Definition of SCF (Speed Correlation Factor)

Where:-

R = Compression Ratio:
B = Bore, mm;
S = Stroke, mm;
CN = No. of Cylinders;
VNI = No. of Inlet Valves per Cylinder;
IVD = Inlet Valve Head Diameter, mm;
IVL = Inlet Valve Maximum Lift, mm;
IOD = Inlet Valve Open Duration, (Valve Off/On Seat), Crank Degrees; at operating clearance, cold.
IVP = Inlet Charge Pressure at Valve, Atmospheres Absolute (ATA) (taken as 1 for Normally Aspirated);
VIA = Included Angle between Valves, Degrees;
IVA = Total Inlet Valve Head Area = CN x VNI x (Pi/4) x $(IVD/10)^2$ sq cm;
PA = Total Piston Area = CN x (Pi/4) x $(B/10)^2$ sq cm;
V = Total Swept Volume = PA x (S/10) cc;

and:-

NP = Crank RPM at Peak Power;

then **NP** is correlated in terms of **SCF**, which is simplified from a multiple regression anaysis of a sample of over 200 engines of all types and which has then been modified manually with two further factors by observation of variances, so that:-

$$\mathbf{SCF} = \sqrt{\left\lfloor \frac{\mathbf{R \times (CN \times VNI \times Pi \times IVD) \times IOD \times (IVL \times IVP)^{1/3}}}{\mathbf{V \times [\cos(VIA/2)]^{1/2}}} \right\rfloor} \times \mathbf{YA} \times \mathbf{YB}$$

and

$$\mathbf{YA} = 3.14 + (2/3) \times \left\lceil \frac{\mathbf{R \times VIA}}{\mathbf{1000}} \right\rceil - 1.1 \times \left\lceil \frac{\mathbf{R \times VIA}}{\mathbf{1000}} \right\rceil^2$$

YA has a maximum at (R x VIA) = 303

$$\mathbf{YB} = 3/4 + 2.1 \times \left\lceil \frac{\mathbf{IVA}}{\mathbf{PA}} \right\rceil - 3.8 \times \left\lceil \frac{\mathbf{IVA}}{\mathbf{PA}} \right\rceil^2$$

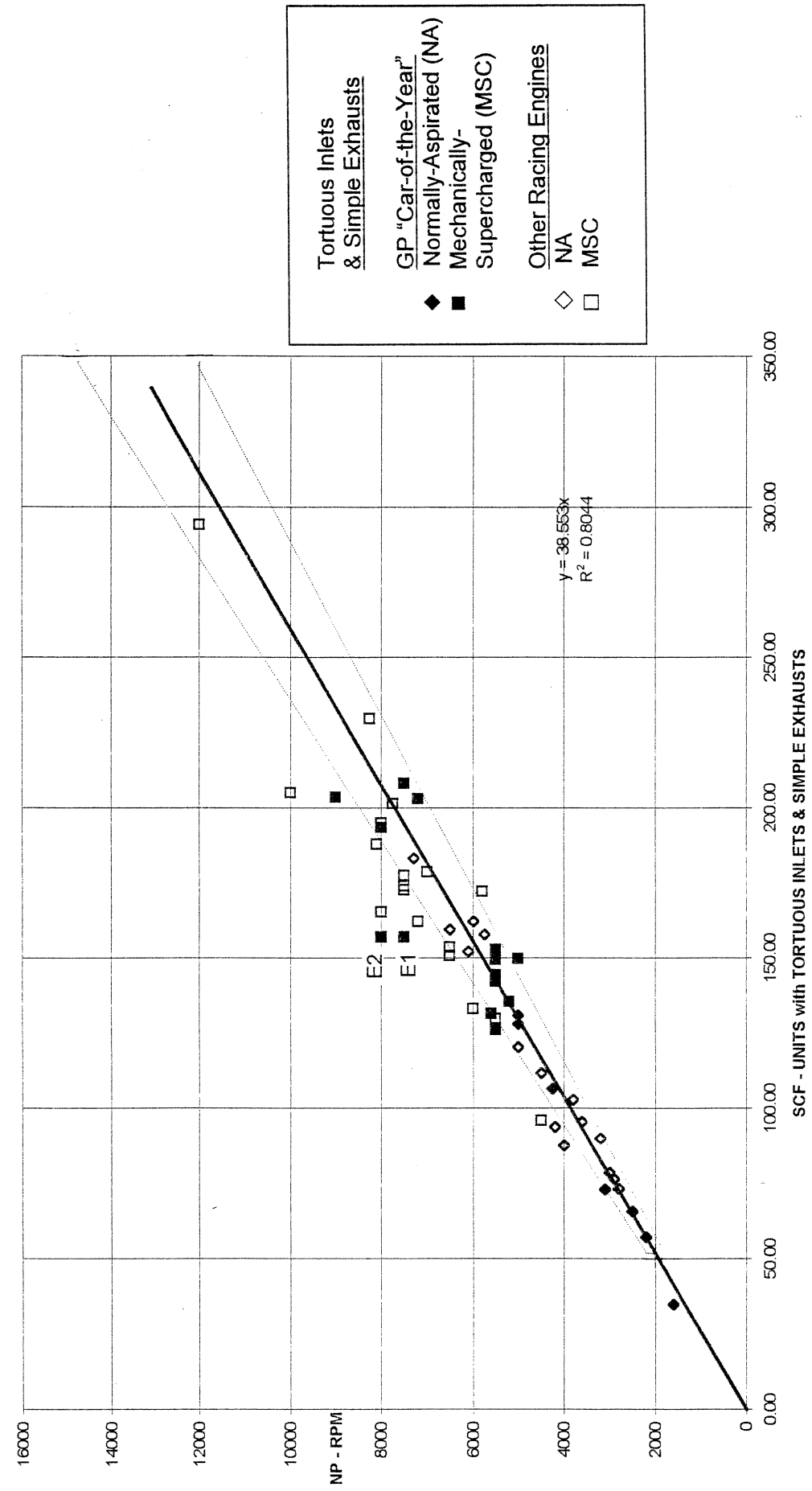
YB has a maximum at (IVA/PA) = 0.276, although results suggest the true maximum should be 0.32.
The equation for **YB** does not apply below (IVA/PA) = 0.1, since it should be 0 when (IVA/PA) = 0.

Note that the term (CN x VNI x Pi x IVD) = TIVC = Total Inlet Valve Head Circumference mm.

The Dimensions of **SCF** are:- $1/(mm^{5/6} \times \sqrt{1000})$

The value of the Gradient **GS = NP/SCF** depends mainly on the quality of the Inlet and Exhaust Systems. The highest figure (around 47.4) is produced from Individual, Fully-Tuned tracts at inlet and exit from the cylinders and the lowest (around 38.6) from multiple cylinders fed from one carburettor by untuned and tortuous tracts and with an untuned exhaust system.

GRAND PRIX ENGINE DEVELOPMENT 1906-1998 NP v. SCF FIGURE 93/DST



GRAND PRIX ENGINE DEVELOPMENT 1906-1998 NP v. SCF FIGURE 94/DST